

A MULTI-PARAMETER APPROACH FOR CALCULATING CRACK INSTABILITY

M. Zanganeh¹ and R.G. Forman¹

¹ NASA Johnson Space Center, Houston, Texas, USA

mohammad.zanganehgheshlaghi@nasa.gov

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Abstract: An accurate fracture control analysis of spacecraft pressure systems, boosters, rocket hardware and other critical low-cycle fatigue cases where the fracture toughness highly impacts cycles to failure requires accurate knowledge of the material fracture toughness. However, applicability of the measured fracture toughness values using standard specimens and transferability of the values to crack instability analysis of the realistically complex structures is refutable. The commonly used single parameter Linear Elastic Fracture Mechanics (LEFM) approach which relies on the key assumption that the fracture toughness is a material property would result in inaccurate crack instability predictions.

In the past years extensive studies have been conducted to improve the single parameter (K-controlled) LEFM by introducing parameters accounting for the geometry or in-plane constraint effects [1]. Despite the importance of the thickness (out-of-plane constraint) effects in fracture control problems, the literature is mainly limited to some empirical equations for scaling the fracture toughness data [2,3] and only few theoretically based developments can be found [4]. In aerospace hardware where the structure might have only one life cycle and weight reduction is crucial, reducing the design margin of safety by decreasing the uncertainty involved in fracture toughness evaluations would result in lighter hardware. In such conditions LEFM would not suffice and an elastic-plastic analysis would be vital.

Multi-parameter elastic plastic crack tip field quantifying developments [5] combined with statistical methods [6] have been shown to have the potential to be used as a powerful tool for tackling such problems. However, these approaches have not been comprehensively scrutinized using experimental tests. Therefore, in this paper a multi-parameter elastic-plastic approach has been used to study the crack instability problem and the transferability issue by considering the effects of geometrical constraints as well as the thickness. The feasibility of the approach has been examined using a wide range of specimen geometries and thicknesses manufactured from 7075-T7351 aluminum alloy.

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